In cooperation with the City of Austin

Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) and Major and Trace Elements in Simulated Rainfall Runoff From Parking Lots, Austin, Texas, 2003

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Abstract

Samples of creek bed sediment collected near seal-coated parking lots in Austin, Texas, by the City of Austin during 2001–02 had unusually elevated concentrations of polycyclic aromatic hydrocarbons (PAHs). To investigate the possibility that PAHs from seal-coated parking lots might be transported to urban creeks, the U.S. Geological Survey, in cooperation with the City of Austin, sampled runoff and scrapings from four test plots and 13 urban parking lots. The surfaces sampled comprise coal-tar-emulsion-sealed, asphalt-emulsion-sealed, unsealed asphalt, and unsealed concrete. Particulates and filtered water in runoff and surface scrapings were analyzed for PAHs. In addition, particulates in runoff were analyzed for major and trace elements. Samples of all three media from coal-tar-sealed parking lots had concentrations of PAHs higher than those from any other types of surface. The average total PAH concentrations in particulates in runoff from parking lots in use were 3,500,000, 620,000, and 54,000 micrograms per kilogram from coal-tar-sealed, asphalt-sealed, and unsealed (asphalt and concrete combined) lots, respectively. The probable effect concentration sediment quality guideline is 22,800 micrograms per kilogram. The average total PAH (sum of detected PAHs) concentration in filtered water from parking lots in use was 8.6 micrograms per liter for coal-tar-sealed lots; the one sample analyzed from an asphalt-sealed lot had a concentration of 5.1 micrograms per liter and the one sample analyzed from an unsealed asphalt lot was 0.24 microgram per liter. The average total PAH concentration in scrapings was 23,000,000, 820,000, and 14,000 micrograms per kilogram from coal-tar-sealed, asphalt-sealed, and unsealed asphalt lots, respectively. Concentrations were similar for runoff and scrapings from the test plots. Concentrations of lead and zinc in particulates in runoff frequently exceeded the probable effect concentrations, but trace element concentrations showed no consistent variation with parking lot surface type.

Introduction

Contamination of aquatic sediments by polycyclic aromatic hydrocarbons (PAHs), which represent the largest class of suspected carcinogens (Björseth and Ramdahl, 1985), has been increasing over the last 20 to 40 years (Van Metre and others, 2000). PAHs in the environment largely are a product of the incomplete combustion of petroleum, oil, coal, and wood (Edwards, 1983). Suspected sources in the urban environment include vehicles, home heating with wood and coal, and power plants (Sims and Overcash, 1983).

During 2001–02, samples of creek bed sediment collected near seal-coated parking lots in Austin, Tex., by the City of Austin had unusually elevated PAH concentrations (Austin American Statesman, 2003a). In 2003, sediment collected by the City of Austin from several parking lot surfaces in Austin had PAH concentrations that exceeded sediment quality guidelines for health of benthic aquatic organisms (MacDonald and others, 2000) by more than two orders of magnitude, prompting city staff to theorize that the sealers coating the parking lots could be the cause (Austin American Statesman, 2003b).

In the United States, sealers are applied to parking lots and driveways to enhance appearance and to protect the underlying asphalt pavement. The most commonly used sealers have a coal-tar-emulsion base, although asphalt-emulsion-based sealers also are available. Reapplication is recommended about every 2 to 3 years. City of Austin staff estimate that about 660,000 gallons (2,500 cubic meters) of coal-tar-emulsion-based sealers are used annually in Austin (City of Austin, 2004). Although figures on national use are not available, The Blue Book of Building and Construction, a directory for the construction industry (Contractors Register, Inc., 2004), lists more than 3,500 pavement sealer companies in 30 states. As an example of sealer use, one commercial sealer applicator, New England Sealcoating, estimates that it has sealed more than 325,000,000 square feet (about 30 square kilometers) of pavement (New England Sealcoating, 2003).

Although coal-tar-emulsion-based and asphalt-emulsion-based sealers are both shiny black, they are produced through

Table 1. Selected characteristics of sites for sampling simulated rainfall runoff from parking lots, Austin, Texas, 2003.

[--, not applicable]

Type of site	USGS site ID	Site name	Type of surface	Date sealant applied
Test plot	301725097415201	MON	coal-tar-emulsion-sealed	August 5–6, 2003
Test plot	301724097415101	TAR	coal-tar-emulsion-sealed	August 5–6, 2003
Test plot	301726097415301	PAV	asphalt-emulsion-sealed	August 5–6, 2003
Test plot	301724097415201	ASP	unsealed asphalt	--
Synoptic/parking lot in use	301431097465201	CNR	coal-tar-emulsion-sealed	July 2003
Synoptic/parking lot in use	301705097434001	LBJ	coal-tar-emulsion-sealed	July 2003
Synoptic/parking lot in use	301622097415801	OSL	coal-tar-emulsion-sealed	July 1999
Synoptic/parking lot in use	302337097402601	TCQ	coal-tar-emulsion-sealed	March 2003
Synoptic/parking lot in use	301533097431201	UNF	coal-tar-emulsion-sealed	November 2000
Synoptic/parking lot in use	301726097441801	UTN	coal-tar-emulsion-sealed	July 2003
Synoptic/parking lot in use	302640097481601	SSE	asphalt-emulsion-sealed	June 2003
Synoptic/parking lot in use	301651097434901	SOC	asphalt-emulsion-sealed	July 2003
Synoptic/parking lot in use	302724097475701	WWB	asphalt-emulsion-sealed	June 2003
Synoptic/parking lot in use	302700097443101	LAC	unsealed concrete	--
Synoptic/parking lot in use	302153097442301	LOW	unsealed concrete	--
Synoptic/parking lot in use	302003097450301	NWR	unsealed asphalt	--
Synoptic/parking lot in use	301557097462701	ZLK	unsealed asphalt	--

different processes and have different molecular structures. Coal tar is derived from the destructive distillation of coal to produce coke and gas or gas. Coal tar is 50-percent or more PAHs by weight (U.S. Department of Health and Human Services, 2002), and coal-tar-emulsion-based sealers typically are 20- to 35-percent coal tar by weight (for example, STAR, Inc., 1996; Neyra Industries, 2000; SealMaster, 2002). Coal tar is a known human carcinogen, and wastes containing coal tar are subject to reporting under the U.S. Environmental Protection Agency's hazardous waste disposal rule (U.S. Department of Health and Human Services, 2002). In contrast, asphalt is derived from the refining of crude petroleum and contains concentrations of PAHs that are several orders of magnitude less than coal tar (Takada and others, 1990). Analyses of commercially available coal-tar-emulsion-based sealers indicated concentrations of total PAH (sum of 16 parent PAHs) ranging from 5 to 600 times greater than those in asphalt-emulsion-based sealers (City of Austin, 2004).

Data collected by the City of Austin indicate that parking lot sealers contain extremely high concentrations of PAHs compared to those in aquatic sediments and compared to sediment quality guidelines. The questions remain, however, whether PAHs from parking lot sealers are mobile and whether they might contribute to the high concentrations of PAHs often found in urban waterways. The purpose of this study was to determine concentrations and loads of PAHs in runoff from different types of parking lot surfaces, and to the extent possible, to determine to what degree parking lot sealers are a source of urban PAHs. To investigate the possibility that PAHs from sealed parking lots might be transported to urban creeks, the U.S. Geological Survey (USGS), in cooperation with the City of Austin, sampled runoff and scrapings from four test plots and 13 urban parking lots during August 12–October 6, 2003.

Purpose and Scope

The purpose of this report is to present sampling methods used for this study and the resulting chemical data. Two experimental approaches were taken: (1) repeated sampling of four test plots (three newly sealed and one unsealed) not exposed to vehicle use, and (2) synoptic sampling of parking lots in use with different types of surfaces, both sealed and unsealed. The test plots were in the parking lot at Robert Mueller Municipal Airport, Austin, Tex., which has not been in use since 1999. Immediately before the beginning of the study, a coal-tar-emulsion sealer was applied to two of the test plots, an asphalt-emulsion-sealer was applied to one of the test plots, and a control site was not sealed (the entire lot was sealed many years ago, but the sealer appears to have worn off) (table 1). Three

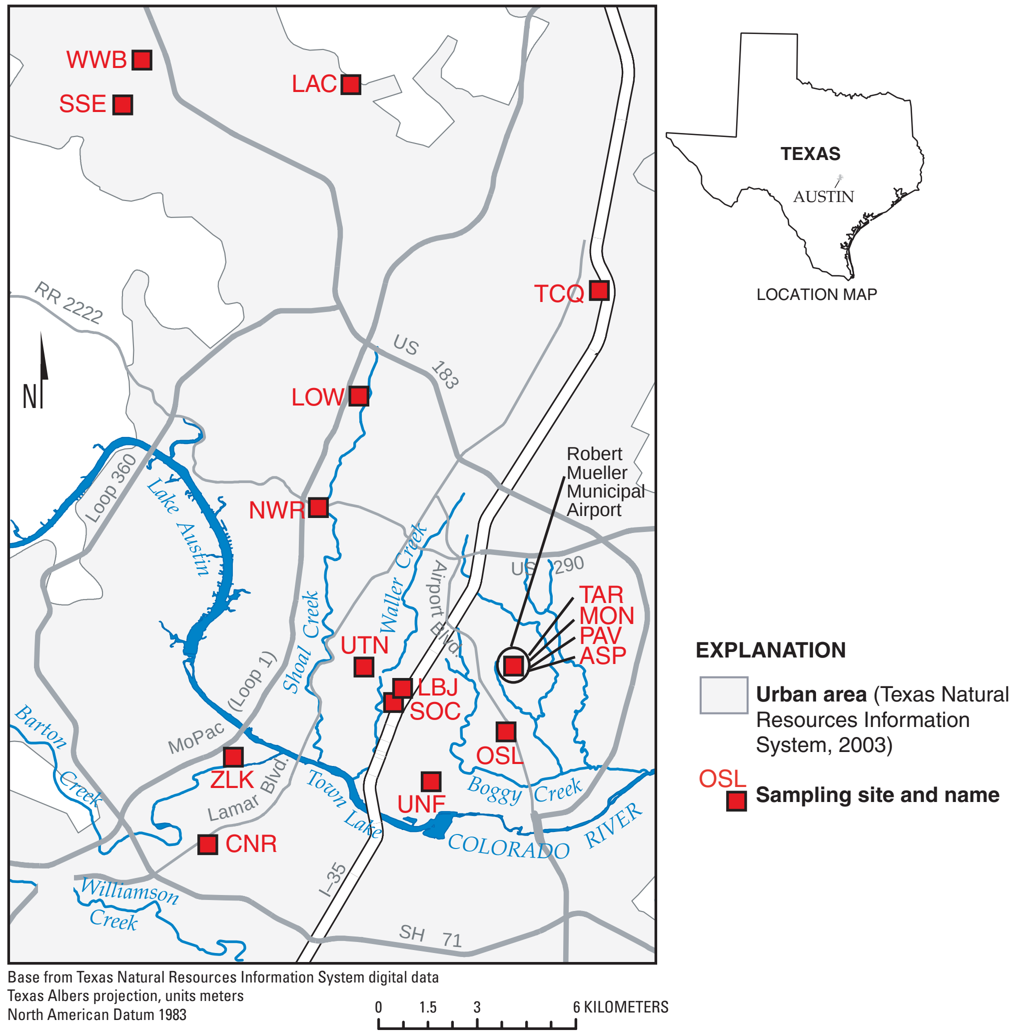

Figure 1. Location of parking lots for sampling of simulated runoff, Austin, Texas, 2003.

times during the 2-month period following application of sealer, distilled deionized (DI) water was applied to the sites using a gentle spray and the washoff was sampled. The sites for the synoptic sampling were in the urban area of Austin (fig. 1). Coal-tar-emulsion-based sealer was applied to six of the parking lots, asphalt-emulsion-based sealer was applied to three parking lots, two lots were unsealed asphalt, and two lots were unsealed concrete (table 1). Each site was sampled once, using the same approach as that used for the test plots. Because the washoff was assumed to contain atmospherically deposited particulates and, in the case of the parking lots in use, particulates from vehicle tires and undercarriages, scrapings of the parking lot surface from most of the sites were analyzed to determine the chemical composition of the surface. Washoff samples were analyzed for a suite of PAHs, major elements, and trace elements in the particulate phase; the scrapings were analyzed for the same suite of PAHs. At a subset of sites, PAHs in the dissolved phase also were analyzed.

Site Selection

The test plots were in the parking lot of Robert Mueller Municipal Airport (fig. 1). The airport was closed in 1999, and the parking lot has been in minimal use since then. Sometime before 1999, a coal-tar sealer was applied, which appeared to have worn off by the time of this study. Three of the test plots are 11- by 11-meter areas that were sealed during August 5–6, 2004 (table 1). The City of Austin arranged for a commercial pavement-sealing company to apply a coal-tar sealer (less than 34-percent coal tar by weight) to one site (TAR) and an asphalt sealer (less than 35-percent asphalt resin by weight) to one site (PAV). An off-the-shelf coal-tar sealer (33-percent coal tar by weight), of the type used for homeowner application to residential driveways, was applied to one site (MON) by City of Austin staff following the manufacturer's instructions. No sealer was applied to the control site (ASP). The test plots received

virtually no vehicle traffic during the 2-month duration of the sampling.

The parking lots for the synoptic sampling were chosen by City of Austin and USGS personnel to represent a range of surface types and sealer ages (table 1). The type of sealer used and date of sealer application were determined on the basis of information provided by the property owner or manager or from the company that sealed the parking lot. Parking lots of schools, government agencies, municipal facilities, and commercial businesses were chosen to sample various locations in the Austin urban area (fig. 1); all parking lots receive daily vehicle traffic.

Sample-Collection Methods

Parking lots were sprinkled with simulated rainfall following a minimum of 5 dry days. Rainfall runoff was simulated using 100 liters of DI water sprayed onto a 5- by 10-meter area of the test plots and parking lots. The only exception was the sampling of the test plots on August 12, 2003, when 25 liters of water on a 2.5- by 5-meter area was used on all the test plots except TAR, the test plot with a commercially applied coal-tar sealer (the smaller volume of water was used because it was immediately obvious that insufficient particulates were available for analysis, so samples for analysis of dissolved PAH only were collected). In one instance it rained during the sampling, and actual rainfall runoff was collected instead of the simulated rainfall (TAR test plot, August 26, 2003). To simulate rainfall, water was pumped with a peristaltic pump from 50-liter, high-density polyethylene (HDPE) carboys through Tygon tubing and a plastic hand-held sprayer (spray rate of about 7 liters per minute) and sprinkled onto the parking lot surface from a height of about 0.75 to 1 meter. Water was blocked at the downslope end of the site either with boards to which weather-stripping had been attached (test plots, August 12 and 21, 2003) or with urethane spill berms (all other samples). The collected runoff was pumped into HDPE carboys through Tygon tubing using a second peristaltic pump. Sampling equipment was cleaned between sites with phosphate-free detergent and then rinsed with tap water, DI water, and methanol.

Samples were pre-processed for analysis at the USGS laboratory in Austin. Samples were filtered through 0.45-micron pore size, polytetrafluoroethylene (PTFE) filters following the methods of Mahler and Van Metre (2003). Samples for analysis of suspended sediment concentration were collected periodically from the churn prior to filtering to allow quantification of the mass of sediment recovered in the sample. A stainless steel plate filter holder was used for filtration of particulates for PAH analysis. The filters were massaged inside of locking bags to remove retained particles, and the recovered particles were shipped as chilled slurries in cleaned glass vials to the USGS National Water Quality Laboratory (NWQL) for analysis. In some cases the filtrate also was shipped, chilled and in clean amber glass bottles, to the NWQL for analysis of dissolved PAH. An acrylic filter holder was used for filtration of particulates for major and trace element analysis. The recovered particulates were freeze-dried and ground before submitting to the NWQL. In all cases, sample-processing equipment was cleaned between samples with phosphate-free detergent, then rinsed with tap water followed by DI water. All equipment used for processing samples for PAH analysis was given a final rinse with methanol.

The test plot and parking lot scrapings were obtained by scraping a small area (less than 0.25 square meter) with a metal paint scraper. The particulates removed were brushed onto a piece of new cardstock and then into a cleaned glass jar. The paint scraper was cleaned between sites in the same manner as the other sampling equipment, and a new brush was used at each site.

Analytical Methods

PAHs in the Particulate Phase

Samples were prepared by extracting about 0.5 gram dry weight of sample (mean 0.47 gram, range 0.10 to 1.36 grams) using pressurized liquid extraction at 120 and 200 degrees Celsius with a mixture of water and isopropyl alcohol (50:50 and 20:80 for the two temperatures, respectively). The samples were extracted for 40 minutes at each temperature at a pressure of 13,790 kilopascals. Surrogate compounds were added to the sample prior to extraction to verify method recoveries. Following extraction, a buffer was added to the extract, and the extract was cleaned using polystyrene divinylbenzene and florisil solid-phase extraction cartridges. The extract was concentrated, solvent exchanged to ethyl acetate, and diluted to 10 milliliters. An internal standard mixture was added to an aliquot of the extract, and the extract was analyzed by full scan on a Hewlett-Packard 5973 gas chromatography/mass spectrometry (GC/MS) system. Difficult sample matrices were diluted before the full-scan analysis, and diluted surrogates were estimated in the samples.

Compound identifications were based on comparison of gas chromatographic peak retention times and mass spectra to those of authentic standard compounds for the target compounds. Response factors were calculated for each compound from a set of calibration standards. For many of the alkyl-substituted PAHs, no authentic standard compounds were available, so the isomers were identified by matching mass spectra in samples with known mass spectra in computerized reference library software (National Institute of Standards and Technology, 2002). The alkyl-substituted PAHs for which standards were not available were quantified using response factors generated from one of the authentic alkyl-homologue compounds in the same alkyl-homologue series. For example, there was no authentic standard for the C4-naphthalene homologue group, so the response factor generated in the calibration standards for 2,6-dimethylnaphthalene was used for its quantitation. The parent PAH response factor was used when no authentic standard was available for a related alkyl-substituted compound within

the same homologue series. Quantitation was done following the methods of Olson and others (in press).

For PAHs in the particulate phase, the estimated method reporting level (MRL) is 5 micrograms per kilogram (µg/kg) for a 25-gram sample. If less than 25 grams was extracted, the MRL was raised accordingly. In some cases, MRLs were raised because of background interferences.

PAHs in the Dissolved Phase

Samples were analyzed following the method described in Fishman (1993), with the difference that continuous liquid-liquid extraction was substituted for use of the separatory funnel. In brief, 1-liter samples fortified with surrogate compounds were extracted by continuous liquid-liquid extraction for 6 hours under acidic then basic conditions. Internal standards were added and sample extracts concentrated to 1 milliliter. Samples were analyzed by GC/MS in electron impact mode. Sample identifications were made by matching retention times and mass spectra with those of standard compounds. Quantitation involved use of internal standards and calibration curves generated by standard compounds of known amounts.

Major and Trace Elements in the Particulate Phase

For major and trace element analyses, samples were freeze-dried and ground to a powder, and elemental concentrations (with the exception of mercury) were determined on concentrated-acid digests (nitric-hydrofluoric-perchloric acids) by inductively coupled plasma/mass spectrometry (ICP/MS) (Briggs and Meier, 2003). Concentrations of mercury were determined by cold-vapor atomic adsorption spectroscopy (Brown and others, 2003).

Quality-Control Samples

Quality-control (QC) samples consist of environmental QC samples and internal laboratory QC samples. Results of QC analyses are summarized below, and detailed results are available from the USGS office in Austin upon request. For this study, two duplicate samples for analysis of particulate PAH were collected, one from a site with extremely elevated particulate PAH concentrations (greater than 4,000,000 µg/kg total particulate PAH [ΣPAH_{part}]). ΣPAH_{part} is defined here as the sum of concentrations of 12 parent PAHs (naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[a]pyrene, and dibenzo[a,h]anthracene) and 2-methylnaphthalene (Ingersoll and others, 2000). For one of the duplicate samples, ΣPAH_{part} differed by 8 percent (relative percent difference); for the second duplicate (sample with elevated concentrations), ΣPAH_{part} differed by 54 percent. One equipment blank was analyzed for dissolved PAH. Three parent PAHs—fluoranthene, phenanthrene, and pyrene—were detected in the blank, but at concentrations more than an order of magnitude less than the MRL. The concentrations were about one-half the concentrations in the environmental sample with the lowest concentrations (ZLK) and less than 1 percent of concentrations in the environmental sample with the highest concentrations (MON).

Laboratory QC samples for particulate PAH analyses consisted of analysis of spiked samples, blanks, and samples of certified reference material (CRM). The surrogate, spike, and CRM values were reported in percent recovered. The method spike was spiked at 20 µg/kg. Because a custom method was used, with limited recovery data, QC criteria are provisional. Representative spike recovery and precision data can be found in Furlong and others (1996). Recovery of the six spiked samples ranged from 6 to 107 percent with a median of 76 percent. For the six laboratory blanks, an analyte was detected in 85 of 336 possible cases, but only 22 detected concentrations were greater than the MRL. The detected concentrations ranged from 0.1 to 3.5 percent of the lowest concentration for that analyte in an environmental sample. For the two analyses of CRM, the recoveries were within the NWQL-established acceptable range for 83 percent of the cases.

Five duplicate samples were analyzed for major and trace elements. Median relative percent difference between the duplicate and environmental samples was 4 percent, with a 25^{th} percentile of 1.4 percent and a 75^{th} percentile of 13 percent. Precision and accuracy of analyses of CRMs, performed internally by the NWQL, were within acceptable limits established by the laboratory (Briggs and Meier, 2003).

PAHs and Major and Trace Elements in Simulated Rainfall Runoff

Results for PAHs, major and trace elements, and suspended sediment concentrations in the simulated rainfall runoff samples are listed in tables 2–5 (at end of report). The "E" qualifier preceding a concentration in the tables indicates that the value is estimated. It is used when QC criteria continually failed upon rerunning samples or when compound quantification was questionable because of interferences. The "E" qualifier also precedes a concentration when it is less than the MRL, when the analyte failed the lab-spike criteria, and for all of the alkyl-homologue groups for which authentic standards are unavailable.

PAHs

Runoff From Test Plots

The test plots were washed off three times during the course of 2 months. Concentrations of ΣPAH_{part} during the

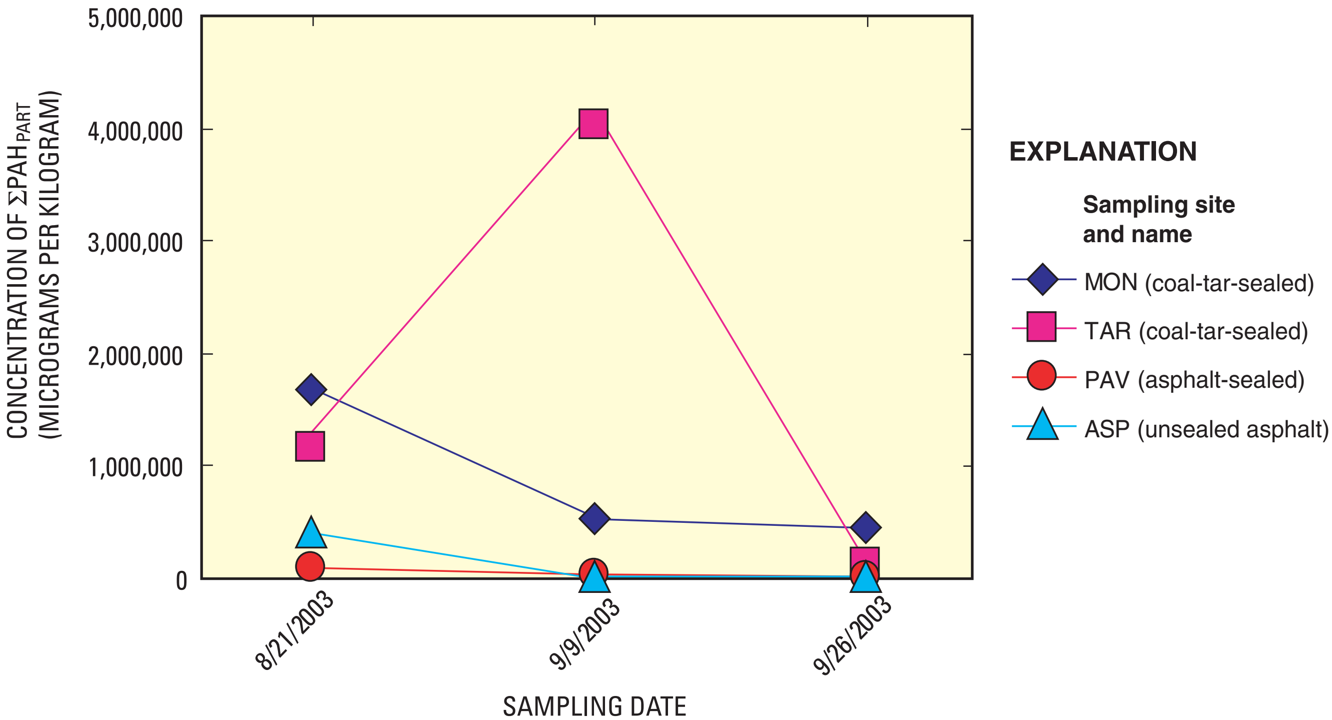

Figure 2. Concentrations of total particulate polycyclic aromatic hydrocarbons (ΣPAH_{part}) in runoff samples from four test plots in Austin, Texas, 2003.

three washoff samplings for the four types of surfaces are shown in figure 2. ΣPAH_{part} concentrations in the simulated rainfall runoff for each washoff sampling were greater in the coal-tar-sealed test plots than in the asphalt-sealed and unsealed test plots (table 2). Concentrations at three of the test plots, including the control site (ASP), decreased during the course of the three washoff samplings; concentration at one of the coal-tar-sealed test plots increased then decreased. The probable effect concentration (PEC), the concentration above which adverse effects on benthic biota are expected to occur more often than not (MacDonald and others, 2000), is 22,800 µg/kg for ΣPAH_{part}. Concentrations of ΣPAH_{part} exceeded the PEC in all samples except the final sample collected at the control site.

Concentrations of total dissolved PAH (ΣPAH_{diss}, defined as the sum of the same PAHs as ΣPAH_{part} excluding 2-methylnaphthalene) during the three washoff samplings are shown in figure 3. ΣPAH_{diss} concentrations were about an order of magnitude greater in samples from the coal-tar-sealed test plots than concentrations in samples from the asphalt-sealed test plot, which in turn were about an order of magnitude greater than those from the unsealed test plot (control site ASP). Concentrations decreased over time at all sealed test plots but generally stayed the same at the control site. Of 17 PAHs analyzed for, nine were detected (table 3). Four PAHs (acenaphthylene, acenaphthene, chrysene, and fluorene) were detected only in runoff from the coal-tar-sealed test plots; anthracene was detected in runoff from all the sealed test plots but not from the control site.

Runoff From Parking Lots in Use

Concentrations of ΣPAH_{part} in simulated rainfall runoff samples from parking lots in use are shown in figure 4, grouped by type of surface. The average ΣPAH_{part} concentrations in runoff from parking lots in use were 3,500,000 µg/kg (coal-tar-sealed lots), 620,000 µg/kg (asphalt-sealed lots), and 54,000 µg/kg (unsealed asphalt and concrete lots combined). Differences between types of surface were compared using the nonparametric Kruskal-Wallis test; the hypothesis (no difference between groups) was rejected for $p < .1$. The concentration of ΣPAH_{part} in runoff samples from coal-tar-sealed parking lots was significantly greater than concentrations in samples from other types of surface. Differences between concentrations from other groups were not significant in Kruskal-Wallis tests. The concentrations of ΣPAH_{part} in runoff samples from parking lots in use are similar to concentrations in samples from test plots with the same type of surface (fig. 4). ΣPAH_{part} concentrations in all runoff samples from parking lots exceeded the

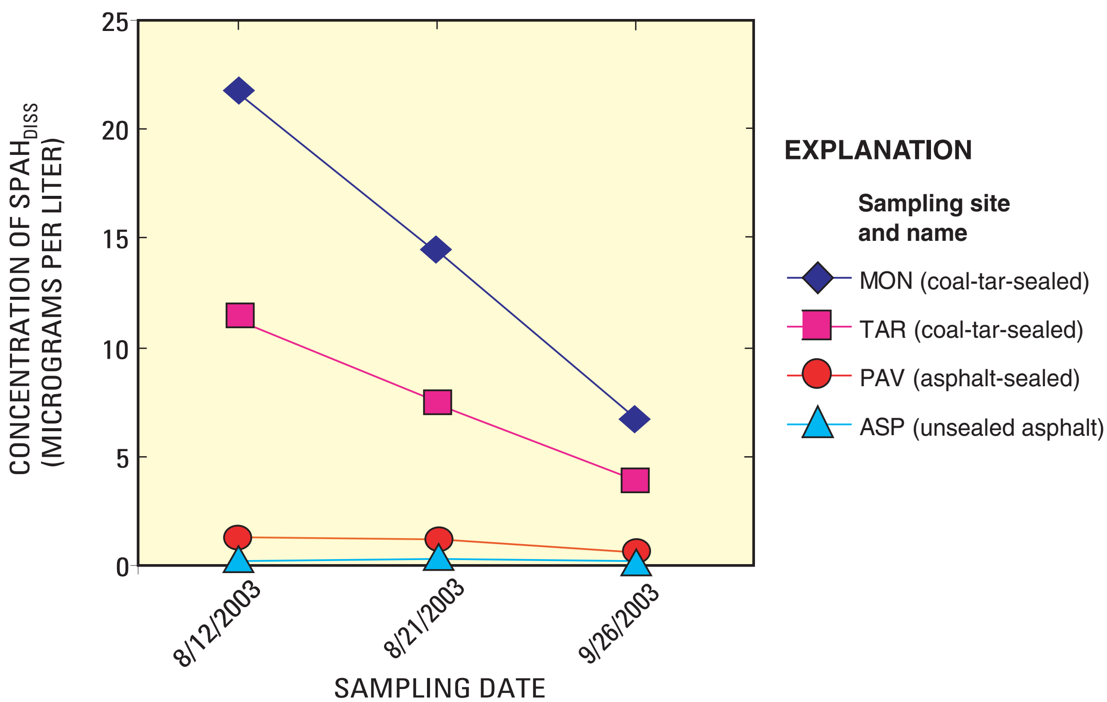

Figure 3. Concentrations of total dissolved polycyclic aromatic hydrocarbons (ΣPAH_{diss}) in runoff samples from four test plots in Austin, Texas, 2003.

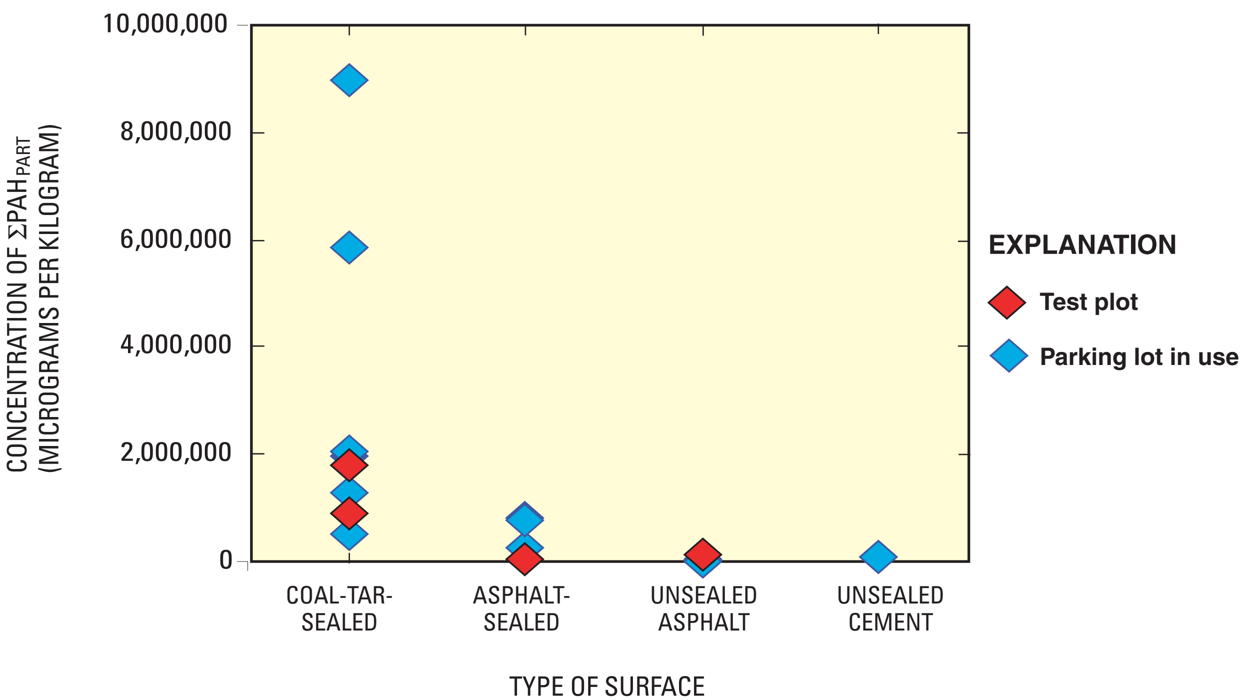

Figure 4. Concentrations of total particulate polycyclic aromatic hydrocarbons (ΣPAH_{part}) in runoff samples from test plots and parking lots in use, Austin, Texas, 2003. Data for test plots is the average of the three washoff samplings at each site.

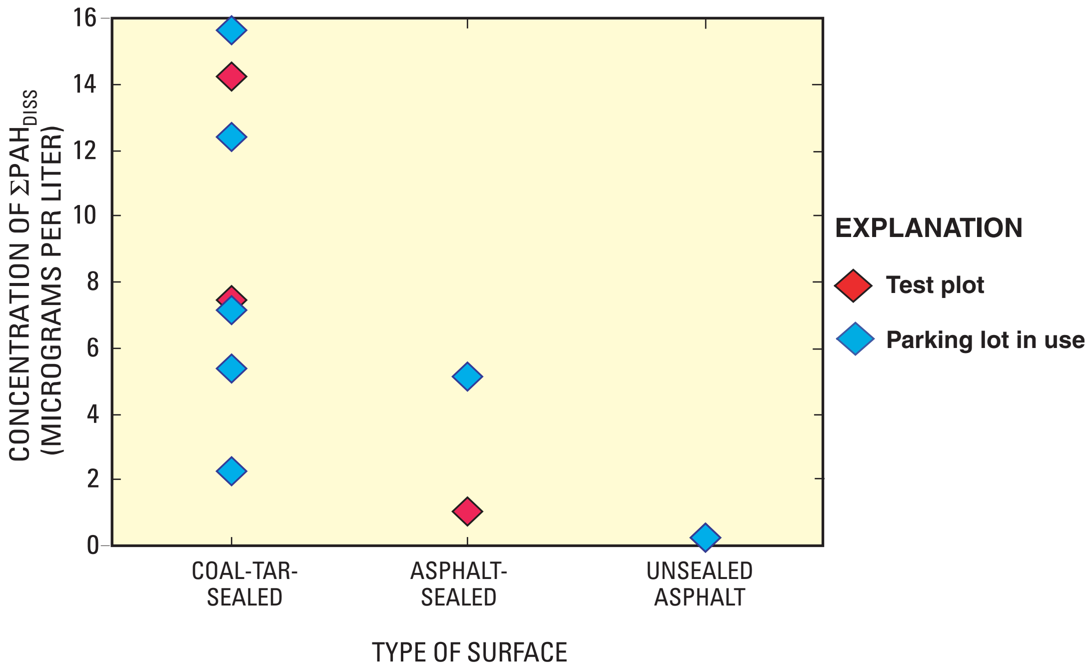

Figure 5. Concentrations of total dissolved polycyclic aromatic hydrocarbons (ΣPAH$_{diss}$) in runoff samples from test plots and parking lots in use, Austin, Texas, 2003. Data for test plots is the average of the three washoff samplings at each site.

PEC (22,800 µg/kg) except in one sample from an unsealed asphalt lot (ZLK, table 2).

Concentrations of ΣPAH$_{diss}$ were analyzed at seven of the 13 parking lots in use (fig. 5, table 3). Only one sample from an asphalt-sealed lot was analyzed, so the difference between sealer types could not be compared statistically. The average ΣPAH$_{diss}$ concentration in filtered water from parking lots in use was 8.6 micrograms per liter (µg/L) for coal-tar-sealed lots; the one sample analyzed from an asphalt-sealed lot had a concentration of 5.1 µg/L, and the one sample analyzed from an unsealed asphalt lot was 0.24 µg/L. Similar to PAHs detected in samples from test plots, acenaphthylene, acenaphthene, and fluorene were detected in samples from one or more of the coal-tar-sealed parking lots but were not detected in samples from the asphalt-sealed or unsealed lots (table 3); however, chrysene was detected in the sample from the asphalt-sealed lot. Concentrations of ΣPAH$_{diss}$ in runoff samples from parking lots in use were similar to those from test plots with the same type of sealer, except the ΣPAH$_{diss}$ concentration in the runoff sample from the asphalt-sealed parking lot, which was about four times greater than the average concentration at the asphalt-sealed test plot (fig. 5).

Scrapings

Scrapings are grouped by type of surface (coal-tar-sealed, asphalt-sealed, and unsealed asphalt) for comparison of ΣPAH$_{part}$ (fig. 6, table 2). The average ΣPAH$_{part}$ concentration in scrapings sampled from coal-tar-sealed lots was 23,000,000 µg/kg, or 28 times the concentration in scrapings from the asphalt-sealed lots (820,000 µg/kg), which in turn was 59 times the concentration in scrapings from the unsealed asphalt lots (14,000 µg/kg). The maximum ΣPAH$_{part}$ concentration detected (83,000,000 µg/kg, or 8.3 percent by weight) was in scrapings of the off-the-shelf coal-tar sealer. ΣPAH$_{part}$ concentrations in scrapings from all sealed test plots or parking lots exceeded the PEC (22,800 µg/kg), and the average concentration in scrapings from coal-tar-sealed lots exceeded the PEC by three orders of magnitude. Concentrations in the two samples of scrapings from unsealed asphalt parking lots (NWR and ZLK) were less than the PEC.

Major and Trace Elements (Metals)

Runoff from Test Plots

Major elements in particulates washed off the test plots were variable from one washoff sampling to the next, and there was no systematic difference in concentrations between type of surface (table 4). PECs have been established for eight trace elements—arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc (MacDonald and others, 2000). During the three washoff samplings, a PEC was exceeded seven times: the PEC for cadmium (4.98 milligrams per kilogram [mg/kg]) was exceeded in one sample from test plot TAR; the PEC for lead (128 mg/kg) was exceeded in one sample each from test plots

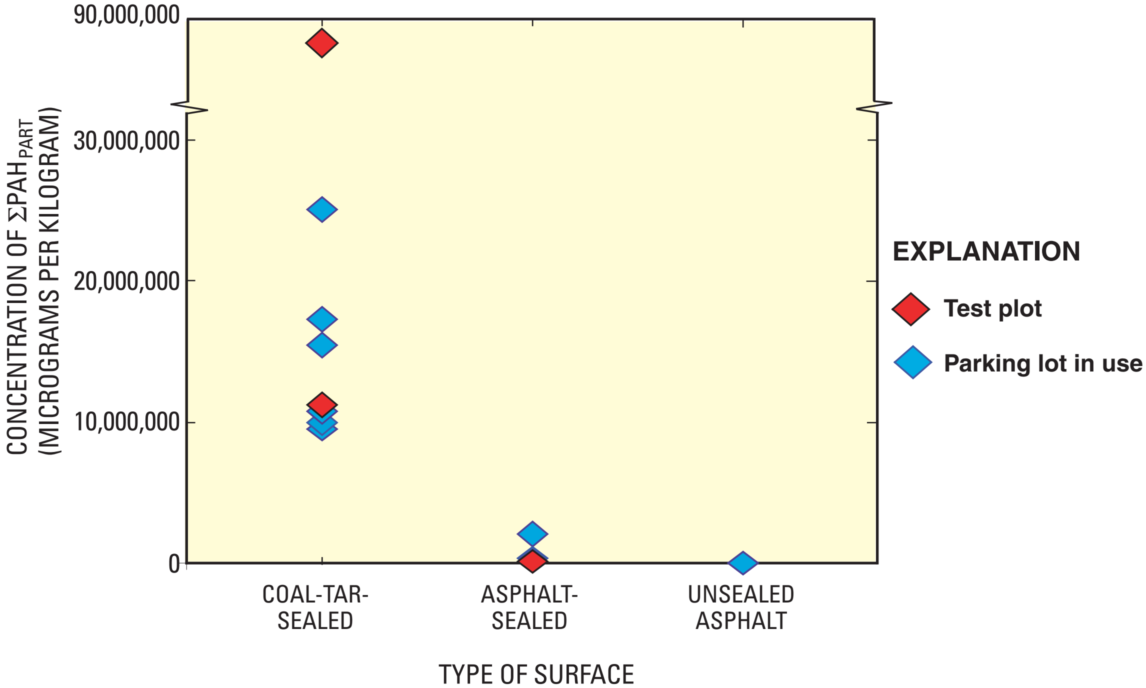

Figure 6. Concentrations of total particulate polycyclic aromatic hydrocarbons (ΣPAH_{part}) in scrapings samples from test plot and parking lot surfaces in Austin, Texas, 2003.

ASP, MON, and PAV; and the PEC for zinc (459 mg/kg) was exceeded in the same samples from ASP, MON, and PAV.

Runoff from Parking Lots in Use

Concentrations of two major elements, calcium and magnesium, were greater in the particulates washed from unsealed parking lots than in those from the sealed parking lots (table 4). Concentrations of other major elements analyzed did not vary on the basis of type of surface. Similar to the results from the test plots, lead and zinc were the trace elements most elevated in particulates washed from the parking lots on the basis of comparison to PECs. The PEC for lead was exceeded in samples from some coal-tar-sealed parking lots (TCQ, OSL, LBJ, and UTN) and in samples from both unsealed concrete lots (LAC, LOW), but the PEC was not exceeded in any of the samples from asphalt-sealed or unsealed asphalt parking lots. The PEC for zinc was exceeded in samples from every parking lot except WWB (asphalt-sealed), ZLK (unsealed asphalt), and OSL (coal-tar-sealed).

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Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003.

[In micrograms per kilogram. ΣPAH_{part}, total particulate polycyclic aromatic hydrocarbons (for complete definition see text); E, estimated; <, less than. Note: Data analyzed by custom method and therefore not available in USGS National Water Information System (NWIS) database.]

Site name	Type of surface	Sampling date	Sample type	Batch no.	ΣPAH_{part}	Phenol	p-Cresol	Naph-thalene	C1-128 isomers, methylated Naphthalenes	2-Ethyl-naph-thalene	2,6- Dimethyl-naph-thalene
Test plots											
MON	coal-tar-emulsion-sealed	8/21/2003	washoff	8022R03238	1,700,000	E3,000	E1,700	12,000	E7,200	E2,000	E2,300
TAR	coal-tar-emulsion-sealed	8/21/2003	washoff	8022R03238	1,200,000	E7,100	E2,000	E6,400	E2,600	<10,000	<10,000
PAV	asphalt-emulsion-sealed	8/21/2003	washoff	8022R03238	96,000	E13,000	E2,200	<19,000	<19,000	<19,000	<19,000
ASP	unsealed asphalt	8/21/2003	washoff	8022R03238	410,000	E1,300	E690	E2,300	<6,700	<6,700	<6,700
MON	coal-tar-emulsion-sealed	9/9/2003	washoff	8022R03245	530,000	<8,500	<8,500	E5,800	<8,500	<8,500	<8,500
TAR	coal-tar-emulsion-sealed	9/9/2003	washoff	8022R03245	4,000,000	<25,000	<25,000	E24,000	<30,000	<25,000	<25,000
PAV	asphalt-emulsion-sealed	9/9/2003	washoff	8022R03245	40,000	5,200	E650	E570	<1,500	<1,000	<1,000
ASP	unsealed asphalt	9/9/2003	washoff	8022R03245	25,000	E690	E410	<1,000	<1,000	<1,000	<1,000
MON	coal-tar-emulsion-sealed	9/26/2003	washoff	8022R03276	460,000	<3,500	<3,500	E2,800	<3,500	<3,500	<3,500
TAR	coal-tar-emulsion-sealed	9/26/2003	washoff	8022R03276	140,000	<3,500	<3,500	<3,500	<3,500	<3,500	<3,500
PAV	asphalt-emulsion-sealed	9/26/2003	washoff	8022R03276	28,000	E2,800	<4,000	<4,000	<4,000	<4,000	<4,000
ASP	unsealed asphalt	9/26/2003	washoff	8022R03276	14,000	<5,000	<5,000	<5,000	<5,000	<5,000	<5,000
MON	coal-tar-emulsion-sealed	8/12/2003	scraping	8022R03245	83,000,000	E20,000	38,000	4,400,000	E1,800,000	120,000	160,000
TAR	coal-tar-emulsion-sealed	8/12/2003	scraping	8022R03245	11,000,000	E7,300	<12,000	64,000	E32,000	E7,400	E10,000
PAV	asphalt-emulsion-sealed	8/12/2003	scraping	8022R03245	110,000	7,300	E1,400	E1,200	<2,500	<2,500	<2,500
Parking lots in use											
TCQ	coal-tar-emulsion-sealed	9/7/2003	washoff	8022R03245	2,000,000	<6,800	<6,800	18,000	E7,500	<6,800	E5,300
SSE	asphalt-emulsion-sealed	9/7/2003	washoff	8022R03245	260,000	E2,600	<6,800	E4,800	<6,800	<6,800	<6,800
SSE duplicate	asphalt-emulsion-sealed	9/7/2003	washoff	8022R03245	240,000	<5,500	<5,500	E4,200	<5,500	<5,500	<5,500
WWB	asphalt-emulsion-sealed	9/7/2003	washoff	8022R03245	830,000	<4,000	<4,000	4,500	E3,600	<4,000	<4,000
LAC	unsealed concrete	9/8/2003	washoff	8022R03245	75,000	<2,500	<2,500	E1,500	<2,500	<2,500	<2,500

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	Type of surface	Sampling date	Sample type	Batch no.	ΣPAH_{part}	Phenol	p-Cresol	Naphthalene	C1-128 isomers, methylated Naphthalenes	2-Ethylnaphthalene	2,6- Dimethylnaphthalene
					Parking lots in use—Continued						
LOW	unsealed concrete	9/8/2003	washoff	8022R03245	69,000	<2,000	<2,000	E1,100	<2,000	<2,000	<2,000
NWR	unsealed asphalt	9/8/2003	washoff	8022R03245	64,000	<4,500	<4,500	E2,900	<4,500	<4,500	<4,500
LBJ	coal-tar-emulsion-sealed	9/28/2003	washoff	8022R03281	9,000,000	E19,000	<17,000	E14,000	E19,000	<17,000	<17,000
UTN	coal-tar-emulsion-sealed	9/28/2003	washoff	8022R03281	2,000,000	E4,600	<4,500	6,700	<4,500	<4,500	<4,500
SOC	asphalt-emulsion-sealed	9/28/2003	washoff	8022R03281	770,000	E14,000	<12,000	<12,000	<12,000	<12,000	<12,000
CNR	coal-tar-emulsion-sealed	9/30/2003	washoff	8022R03276	1,300,000	E2,200	E1,400	E6,500	<3,500	E1,300	<3,500
OSL	coal-tar-emulsion-sealed	9/30/2003	washoff	8022R03276	520,000	<4,000	<4,000	E1,700	<4,000	<4,000	<4,000
UNF	coal-tar-emulsion-sealed	9/30/2003	washoff	8022R03276	7,500,000	E2,900	E2,600	E13,000	E5,200	E2,000	<5,000
UNF duplicate	coal-tar-emulsion-sealed	9/30/2003	washoff	8022R03276	4,300,000	E2,000	E1,500	E9,000	E3,600	E1,400	<3,500
ZLK	unsealed asphalt	9/30/2003	washoff	8022R03276	7,200	<2,000	E2,700	<2,000	<2,000	<2,000	<2,000
TCQ	coal-tar-emulsion-sealed	9/14/2003	scraping	8022R03245	25,000,000	<25,000	E10,000	320,000	E160,000	E23,000	38,000
SSE	asphalt-emulsion-sealed	9/14/2003	scraping	8022R03245	340,000	<12,000	<12,000	E6,000	<12,000	<12,000	<12,000
WWB	asphalt-emulsion-sealed	9/14/2003	scraping	8022R03245	2,000,000	<25,000	<25,000	E17,000	<25,000	<25,000	<25,000
NWR	unsealed asphalt	9/14/2003	scraping	8022R03245	7,100	E270	<500	<500	<600	<500	<500
LBJ	coal-tar-emulsion-sealed	9/28/2003	scraping	8022R03281	15,000,000	E9,300	<8,500	31,000	E89,000	E5,700	12,000
UTN	coal-tar-emulsion-sealed	9/28/2003	scraping	8022R03281	11,000,000	E13,000	<12,000	22,000	<12,000	<12,000	<12,000
CNR	coal-tar-emulsion-sealed	10/6/2003	scraping	8022R03281	9,400,000	E13,000	<12,000	22,000	<12,000	<12,000	<12,000
OSL	coal-tar-emulsion-sealed	10/6/2003	scraping	8022R03281	9,900,000	E12,000	<12,000	17,000	<12,000	<12,000	<12,000
UNF	coal-tar-emulsion-sealed	10/6/2003	scraping	8022R03281	17,000,000	E13,000	<12,000	23,000	<12,000	<12,000	<12,000
ZLK	unsealed asphalt	10/6/2003	scraping	8022R03281	20,000	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	1,6-Dimethyl-naph-thalene	C2-128 isomers, C2-alkyated Naphthalenes	Ace-naph-thylene	1,2-Dimethyl-naph-thalene	Ace-naph-thene	C3-128 somers, C3-alkylated Naph-thalenes	2,3,6-Trimethyl-naph-thalene	9H-Fluorene	C4-128 isomers, C4-alkylated Naph-thalenes	1-methyl-9H-Fluorene	Phenan-threne	Anthra-cene	C5-128 isomers, C5-alkylated Naphtha-lenes	2-Methyl-anthra-cene
Test plots														
MON	E3,200	E5,800	E3,800	<9,000	14,000	<9,000	<9,000	19,000	<15,000	<9,000	310,000	E50,000	<45,000	E7,200
TAR	E3,400	E4,100	E5,000	<10,000	E5,400	<10,000	<10,000	E7,800	<10,000	<10,000	150,000	E29,000	<35,000	E5,700
PAV	<19,000	<19,000	<19,000	<19,000	<19,000	<19,000	<19,000	<19,000	<19,000	<19,000	E13,000	E5,000	<19,000	<19,000
ASP	<6,700	<6,700	E2,900	<6,700	E2,000	<6,700	<6,700	E2,000	<6,700	<6,700	32,000	E6,400	<15,000	E2,900
MON	<8,500	<8,500	<8,500	<8,500	E6,300	<8,500	<8,500	E5,600	<200,000	<8,500	66,000	10,000	<19,000	<8,500
TAR	<25,000	<30,000	36,000	<25,000	31,000	<34,000	<25,000	33,000	<800,000	<25,000	470,000	78,000	<120,000	40,000
PAV	<1,000	<1,500	E490	<1,000	<1,000	<1,000	<1,000	E600	<22,000	<1,000	5,300	1,000	<1,500	<1,000
ASP	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000	E480	<18,000	<1,000	2,200	E560	<1,000	E520
MON	<3,500	<3,500	E1,500	<3,500	<3,500	<3,500	<3,500	E2,200	<61,000	<3,500	66,000	4,400	<3,500	E1,900
TAR	<3,500	<3,500	E1,200	<3,500	<3,500	<3,500	<3,500	E1,600	<58,000	<3,500	12,000	E2,400	<3,500	E1,800
PAV	<4,000	<4,000	<4,000	<4,000	<4,000	<4,000	<4,000	E1,500	<66,000	<4,000	E2,800	<4,000	<4,000	<4,000
ASP	<5,000	<5,000	<5,000	<5,000	<5,000	<5,000	<5,000	<5,000	<46,000	<5,000	E1,400	<5,000	<5,000	<5,000
MON	120,000	E920,000	48,000	57,000	2,700,000	E520,000	40,000	2,800,000	<6,500,000	88,000	19,000,000	4,700,000	<1,800,000	330,000
TAR	E11,000	E36,000	19,000	11,000	14,000	E69,000	E11,000	210,000	<950,000	15,000	2,200,000	540,000	<350,000	41,000
PAV	<2,500	<2,500	E1,000	<2,500	E1,200	<2,500	<2,500	E2,300	<52,000	<2,500	20,000	3,500	<3,500	E1,500
Parking lots in use														
TCQ	E6,400	E8,300	12,000	<6,800	15,000	E8,900	<6,800	15,000	<220,000	E4,300	290,000	21,000	<55,000	8,300
SSE	<6,800	<6,800	7,500	<6,800	<6,800	<6,800	<6,800	E3,800	<160,000	<6,800	28,000	E5,300	<13,000	<6,800
SSE duplicate	<5,500	<5,500	6,400	<5,500	<5,500	<5,500	<5,500	E3,300	<130,000	<5,500	24,000	E4,600	<15,000	<11,000
WWB	<4,000	<4,000	4,900	<4,000	E3,000	<4,000	<4,000	E2,900	<92,000	<4,000	35,000	7,100	<93,000	4,600
LAC	<2,500	<2,500	2,500	<2,500	E1,600	<2,500	<2,500	E1,300	<53,000	<2,500	5,800	E1,500	<3,800	E2,500

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	1,6-Dimethyl-naph-thalene	C2-128 isomers, C2-alkyated Naphthalenes	Ace-naph-thylene	1,2-Dimethyl-naph-thalene	Ace-naph-thene	C3-128 somers, C3-alkylated Naph-thalenes	2,3,6-Trimethyl-naph-thalene	9H-Fluorene	C4-128 isomers, C4-alkylated Naph-thalenes	1-methyl-9H-Fluorene	Phenan-threne	Anthra-cene	C5-128 isomers, C5-alkylated Naphtha-lenes	2-Methyl-anthra-cene
							Parking lots in use—Continued							
LOW	<2,000	<2,000	E2,000	<2,000	E1,300	<2,000	<2,000	E1,000	<40,000	<2,000	5,500	E1,300	<3,100	E1,900
NWR	<4,500	<4,500	E4,200	<4,500	<4,500	<4,500	<4,500	E2,200	<90,000	<4,500	6,600	E2,100	<5,500	<4,500
LBJ	<17,000	<17,000	36,000	<17,000	31,000	<21,000	<17,000	32,000	<340,000	E9,900	960,000	75,000	<200,000	17,000
UTN	<4,500	<4,500	E4,300	<4,500	E2,100	<4,500	<3,500	4,600	<91,000	<4,500	69,000	14,000	<40,000	E4,200
SOC	<12,000	<12,000	E7,600	<12,000	<12,000	<12,000	<12,000	E7,900	<230,000	<12,000	88,000	E12,000	<25,000	E7,900
CNR	<3,500	<3,500	3,800	<3,500	E1,300	<3,500	<3,500	3,600	<65,000	E1,400	94,000	12,000	<9,500	E2,800
OSL	<4,000	<4,000	E2,800	<4,000	<4,000	<4,000	<4,000	E2,200	<69,000	<4,000	21,000	4,800	<12,000	E2,300
UNF	<5,000	<5,000	8,900	<5,000	E3,300	<6,000	<5,000	8,500	<120,000	E2,500	310,000	34,000	<170,000	7,200
UNF duplicate	<3,500	<3,500	5,600	<3,500	E2,400	<3,500	<3,500	5,600	<81,000	<3,500	180,000	20,000	<88,000	4,300
ZLK	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<34,000	<2,000	E720	<2,000	<2,000	<2,000
TCQ	36,000	E150,000	75,000	27,000	420,000	E210,000	32,000	420,000	<1,800,000	37,000	4,500,000	430,000	<670,000	61,000
SSE	<12,000	<12,000	<12,000	<12,000	E9,200	<12,000	<12,000	E7,700	<320,000	<12,000	42,000	<12,000	<18,000	<12,000
WWB	<25,000	<25,000	<25,000	<25,000	E19,000	<25,000	<25,000	E16,000	<590,000	<25,000	120,000	E23,000	<68,000	28,000
NWR	<500	<500	<500	<500	<500	<500	<500	E280	<9,500	<500	970	E230	<500	<500
LBJ	10,000	E53,000	52,000	<8,500	150,000	E72,000	E4,700	120,000	<280,000	9,800	2,900,000	120,000	<360,000	17,000
UTN	<12,000	<12,000	15,000	<12,000	E7,600	<12,000	<12,000	16,000	<260,000	E7,700	460,000	74,000	<230,000	19,000
CNR	<12,000	<12,000	18,000	<12,000	E11,000	<12,000	<12,000	25,000	<420,000	E9,400	850,000	140,000	<230,000	24,000
OSL	<12,000	<12,000	26,000	<12,000	E5,700	<12,000	<12,000	15,000	<260,000	E7,600	390,000	72,000	<200,000	17,000
UNF	<12,000	<12,000	18,000	<12,000	E8,000	<12,000	<12,000	20,000	<310,000	E9,200	1,500,000	100,000	<440,000	25,000
ZLK	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500	<15,000	<8,500	<8,500	<8,500	<8,500	<8,500

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	4,5-Methylene-phenanthrene	C1-178 isomers methylated Phenanthrene/anthracenes	1-Methyl-phenanthrene	C2-178 isomers, C2-alkylated Phenanthrene/anthracenes	Fluoranthene	Pyrene	C3-178 isomers, C3-alkylated Phenanthrene/anthracenes	C4-178 isomers, C4-alkylated Phenanthrene/anthracenes	1-Methyl-pyrene	C1-202 isomers, methylated Fluoranthene/pyrenes	C2-202 isomers, C2-alkylated Fluoranthene/pyrenes	C5-178 isomers, C5-alkylated Phenanthrene/anthracenes
						Test plots						
MON	29,000	E46,000	9,200	E16,000	510,000	340,000	<9,000	<9,000	E8,300	E120,000	E89,000	<15,000
TAR	17,000	E32,000	E7,600	E21,000	320,000	240,000	<20,000	<10,000	E9,600	E99,000	E74,000	<25,000
PAV	E6,300	E8,800	<19,000	<19,000	23,000	E17,000	<19,000	<19,000	<19,000	E11,000	E14,000	<19,000
ASP	E6,700	E11,000	E3,400	E8,600	110,000	85,000	<8,000	<6,700	E5,100	E40,000	E20,000	<9,500
MON	10,000	E18,000	E5,300	E13,000	160,000	110,000	<12,000	<9,500	E8,000	E39,000	E37,000	<12,000
TAR	67,000	E120,000	28,000	E89,000	1,100,000	870,000	<82,000	<46,000	44,000	E340,000	E220,000	<88,000
PAV	<1,000	E1,600	<1,000	E1,400	11,000	7,000	<1,500	<1,000	E540	E2,300	<5,000	<2,000
ASP	<1,000	E1,000	<1,000	<1,000	6,100	4,800	<1,000	<1,000	E460	E2,100	<2,000	<1,000
MON	E2,500	E9,900	E1,700	E4,400	160,000	97,000	<3,500	<3,500	E2,100	E21,000	<45,000	<4,500
TAR	<3,500	E4,400	<3,500	E3,700	38,000	29,000	<3,500	<3,500	E1,900	E12,000	<10,000	<4,000
PAV	<4,000	<4,000	<4,000	<4,000	6,000	4,600	<4,000	<4,000	<4,000	<4,000	<4,000	<4,000
ASP	<5,000	<5,000	<5,000	<5,000	E3,000	E2,600	<5,000	<5,000	E970	<5,000	<5,000	<5,000
MON	1,900,000	E2,700,000	390,000	E680,000	18,000,000	13,000,000	<250,000	<55,000	260,000	E4,200,000	E1,100,000	<350,000
TAR	240,000	E420,000	63,000	E220,000	2,800,000	2,200,000	<150,000	<48,000	69,000	E940,000	E310,000	<150,000
PAV	E1,300	E5,000	<2,500	E4,300	28,000	21,000	<4,000	<2,500	E1,600	E7,400	<7,500	<8,000
						Parking lots in use						
TCQ	23,000	E53,000	11,000	E35,000	580,000	460,000	<24,000	<12,000	15,000	E140,000	E150,000	<32,000
SSE	E5,700	E12,000	E3,800	E10,000	75,000	41,000	<9,500	<8,000	E5,600	E16,000	E34,000	<16,000
SSE duplicate	E4,800	E9,800	E3,300	E8,900	67,000	39,000	<9,000	<7,000	E5,000	E15,000	E29,000	<14,000
WWB	6,200	E16,000	4,200	E14,000	270,000	180,000	<12,000	<6,000	6,200	E59,000	E93,000	<25,000
LAC	E2,100	E3,800	E1,300	E3,500	18,000	15,000	<3,200	<2,700	E2,100	E6,500	E7,000	<3,900

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	4,5-Methylene-phenanthrene	C1-178 isomers methylated Phenanthrene/anthracenes	1-Methyl-phenanthrene	C2-178 isomers, C2-alkylated Phenanthrene/anthracenes	Fluoranthene	Pyrene	C3-178 isomers, C3-alkylated Phenanthrene/anthracenes	C4-178 isomers, C4-alkylated Phenanthrene/anthracenes	1-Methyl-pyrene	C1-202 isomers, methylated Fluoranthene/pyrenes	C2-202 isomers, C2-alkylated Fluoranthene/pyrenes	C5-178 isomers, C5-alkylated Phenanthrene/anthracenes
Parking lots in use—Continued												
LOW	E1,700	E3,200	E1,100	E2,700	17,000	14,000	<2,500	<2,100	E1,600	E5,500	E6,300	<3,100
NWR	E3,100	E5,400	E2,000	E5,200	14,000	12,000	<5,500	<5,000	E3,200	E6,000	E7,200	<6,500
LBJ	61,000	E210,000	45,000	E95,000	2,700,000	2,000,000	<40,000	<17,000	44,000	E320,000	<750,000	<200,000
UTN	12,000	E28,000	7,100	E18,000	520,000	420,000	<10,000	<5,000	13,000	E120,000	<210,000	<24,000
SOC	E8,300	E30,000	E6,700	E20,000	260,000	160,000	<18,000	<12,000	E11,000	E40,000	<69,000	<26,000
CNR	9,500	E28,000	5,300	E23,000	360,000	280,000	<15,000	<7,500	7,300	E95,000	E130,000	<30,000
OSL	E2,500	E10,000	E2,400	E9,200	140,000	100,000	<6,500	<3,500	4,300	E37,000	<67,000	<13,000
UNF	50,000	E120,000	32,000	E67,000	2,200,000	1,800,000	<27,000	<18,000	44,000	E540,000	E710,000	<68,000
UNF duplicate	25,000	E64,000	17,000	E35,000	1,300,000	1,000,000	<16,000	<5,500	22,000	E260,000	E400,000	<38,000
ZLK	<2,000	<2,000	<2,000	<2,000	E1,700	E1,600	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000
TCQ	440,000	E810,000	140,000	E440,000	6,700,000	5,300,000	<260,000	<81,000	160,000	E1,900,000	E1,100,000	<260,000
SSE	E11,000	E21,000	E7,000	E19,000	91,000	73,000	<18,000	<16,000	E11,000	E28,000	E30,000	<22,000
WWB	29,000	E62,000	E18,000	E57,000	580,000	440,000	<54,000	<36,000	29,000	E170,000	E180,000	<80,000
NWR	<500	E500	<500	<500	1,500	1,300	<500	<500	<500	E610	<600	<500
LBJ	150,000	E470,000	90,000	E160,000	4,500,000	3,200,000	<60,000	<12,000	58,000	E490,000	E980,000	<81,000
UTN	100,000	E190,000	46,000	E100,000	3,000,000	2,400,000	<42,000	<17,000	71,000	E690,000	E840,000	<100,000
CNR	130,000	E260,000	50,000	E180,000	2,600,000	2,000,000	<110,000	<43,000	64,000	E700,000	E420,000	<130,000
OSL	81,000	E200,000	45,000	E170,000	2,600,000	2,100,000	<120,000	<30,000	75,000	E660,000	E900,000	<160,000
UNF	210,000	E460,000	96,000	E190,000	5,700,000	4,400,000	<67,000	<17,000	97,000	E920,000	<1,200,000	<100,000
ZLK	<8,500	<8,500	<8,500	<8,500	E5,400	E4,900	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	Benz(a)-anthra-cene	Chrysene	C3-202 isomers, C3-alkylated Fluoranthene/ pyrenes	C1-228 isomers, methylated Benzo(a)-anthracene/ chrysenes	C4-202 isomers, C4-alkylated Fluoranthene/ pyrenes	C5-202 isomers, C5-alkylated Flucoranthene/ pyrenes	C2-228 isomers, C2-alkylated Benzo(a)-anthracene/ chrysenes	Benzo(b)-fluoran-thene	Benzo(k)-fluoran-thene	Benzo(e)-pyrene	Benzo(a)-pyrene	Perylene	C1-252 isomers, C1-methylated Benzopyrene/ perylenes
Test plots													
MON	110,000	190,000	<9,000	E46,000	<35,000	<9,000	<20,000	160,000	110,000	95,000	100,000	26,000	E48,000
TAR	100,000	180,000	<10,000	E54,000	<30,000	<10,000	E24,000	180,000	110,000	100,000	100,000	30,000	E58,000
PAV	E9,200	E17,000	<19,000	E8,900	<19,000	<19,000	<19,000	E14,000	E6,900	E10,000	E12,000	<19,000	<20,000
ASP	44,000	60,000	<6,700	E25,000	<9,000	<6,700	E12,000	61,000	45,000	42,000	53,000	16,000	E30,000
MON	39,000	70,000	<10,000	E25,000	<22,000	<8,500	<16,000	87,000	48,000	46,000	41,000	E8,100	<28,000
TAR	350,000	570,000	<41,000	E210,000	<120,000	<42,000	E120,000	560,000	410,000	370,000	400,000	100,000	<230,000
PAV	1,900	6,000	<1,000	<2,000	<2,000	<1,000	<1,500	5,600	4,500	4,100	3,800	E680	<4,500
ASP	2,800	3,700	<1,000	<2,000	<1,000	<1,000	<1,000	4,200	3,600	3,000	3,500	E920	<4,000
MON	16,000	80,000	<4,000	E12,000	<22,000	<3,500	<6,500	59,000	39,000	38,000	28,000	4,400	<16,000
TAR	14,000	25,000	<3,500	E8,800	<5,000	<3,500	<5,500	21,000	16,000	15,000	17,000	4,400	E13,000
PAV	E2,900	E3,800	<4,000	<4,000	<4,000	<4,000	<4,000	7,600	6,300	5,600	6,200	<4,000	<9,000
ASP	E2,200	E1,900	<5,000	<5,000	<5,000	<5,000	<5,000	E3,700	E3,300	E2,600	E3,400	<5,000	<5,200
MON	5,000,000	5,200,000	<140,000	E1,900,000	<450,000	<150,000	<550,000	4,800,000	4,400,000	3,000,000	4,600,000	1,500,000	E2,000,000
TAR	940,000	1,100,000	<30,000	E430,000	<150,000	<45,000	E200,000	1,000,000	730,000	690,000	920,000	280,000	E460,000
PAV	10,000	13,000	<2,500	E6,500	<5,000	<4,500	E5,900	12,000	9,800	8,900	11,000	3,100	<13,000
Parking lots in use													
TCQ	110,000	310,000	<12,000	E85,000	<77,000	<16,000	<46,000	370,000	170,000	200,000	170,000	33,000	E85,000
SSE	15,000	50,000	<8,000	E18,000	<20,000	<10,000	<16,000	66,000	29,000	40,000	21,000	E2,500	<22,000
SSE duplicate	15,000	47,000	<7,000	E17,000	<16,000	<8,500	<14,000	76,000	20,000	37,000	22,000	E3,700	<20,000
WWB	48,000	190,000	E8,000	E45,000	<42,000	<10,000	E25,000	220,000	99,000	100,000	68,000	17,000	E44,000
LAC	6,800	9,800	<2,500	E6,100	<4,500	<3,000	E4,600	12,000	7,900	9,100	7,600	E1,300	<7,200

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	Benz(a)-anthra-cene	Chrysene	C3-202 isomers, C3-alkylated Fluoranthene/ pyrenes	C1-228 isomers, methylated Benzo(a)-anthracene/ chrysenes	C4-202 isomers, C4-alkylated Fluoranthene/ pyrenes	C5-202 isomers, C5-alkylated Flucoranthene/ pyrenes	C2-228 isomers, C2-alkylated Benzo(a)-anthracene/ chrysenes	Benzo(b)-fluoran-thene	Benzo(k)-fluoran-thene	Benzo(e)-pyrene	Benzo(a)-pyrene	Perylene	C1-252 isomers, C1-methylated Benzopyrene/ perylenes
						Parking lots in use—Continued							
LOW	5,900	9,300	<2,000	E5,100	<3,800	<2,100	<3,800	13,000	7,000	8,400	7,300	E1,300	<6,100
NWR	7,200	6,800	<4,500	E6,900	<6,000	<5,000	<7,500	12,000	5,800	9,200	7,000	<4,500	<9,000
LBJ	590,000	1,500,000	<34,000	E250,000	<240,000	<39,000	<95,000	1,400,000	830,000	820,000	790,000	200,000	E340,000
UTN	180,000	460,000	<9,000	E85,000	<83,000	<12,000	<34,000	450,000	260,000	280,000	250,000	75,000	E120,000
SOC	42,000	120,000	<14,000	E32,000	<30,000	<17,000	<23,000	100,000	68,000	66,000	55,000	15,000	<52,000
CNR	86,000	280,000	<7,000	E70,000	<54,000	<14,000	E36,000	250,000	150,000	160,000	140,000	31,000	E79,000
OSL	42,000	120,000	<4,500	E37,000	<30,000	<7,000	E19,000	100,000	71,000	72,000	63,000	17,000	E41,000
UNF	690,000	1,300,000	<29,000	E370,000	<270,000	<30,000	<140,000	980,000	880,000	740,000	830,000	230,000	E340,000
UNF duplicate	360,000	800,000	<16,000	E190,000	<140,000	<18,000	<72,000	690,000	550,000	480,000	490,000	120,000	E180,000
ZLK	<2,000	E990	<2,000	<2,000	<2,000	<2,000	<2,000	2,400	2,300	E1,600	2,200	<2,000	<4,000
TCQ	1,700,000	2,800,000	E75,000	E980,000	<450,000	<100,000	E460,000	2,300,000	1,400,000	1,700,000	2,000,000	520,000	E930,000
SSE	28,000	41,000	<13,000	E26,000	<22,000	<16,000	<24,000	48,000	30,000	37,000	30,000	E4,100	<32,000
WWB	170,000	380,000	<32,000	E140,000	<95,000	<46,000	E87,000	440,000	270,000	250,000	220,000	56,000	<140,000
NWR	820	870	<500	<700	<500	<500	<600	1,200	1,100	820	1,100	E220	<2,000
LBJ	930,000	1,900,000	<30,000	E330,000	<270,000	<25,000	<120,000	1,600,000	1,300,000	1,100,000	1,200,000	280,000	E410,000
UTN	1,200,000	1,900,000	<33,000	E450,000	<300,000	<44,000	<170,000	1,600,000	1,500,000	1,200,000	1,400,000	440,000	E560,000
CNR	980,000	1,400,000	<26,000	E400,000	<190,000	<53,000	E220,000	1,300,000	700,000	800,000	1,200,000	300,000	E520,000
OSL	1,200,000	1,900,000	<30,000	E530,000	<310,000	<52,000	<270,000	1,700,000	890,000	1,200,000	1,300,000	370,000	E640,000
UNF	1,400,000	2,400,000	<46,000	E460,000	<350,000	<46,000	<160,000	1,800,000	1,600,000	1,300,000	1,500,000	350,000	E510,000
ZLK	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500	<8,500	E6,300	9,700	<8,500	<17,000

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	C3-228 isomers, C3-Benzo(a)-anthracene/ chrysenes	C2-252 isomers, C2-alkylated Benzopyrene/ perylenes	C4-228 isomers, C4-Benzo(a)-anthracene/ chrysenes	Benzo-(g,h,i)-perylene	Indeno-(1,2,3-c,d)-pyrene	Dibenzo-(a,h)-anthra-cene	C3-252 isomers, C3-alkylated Benzopyrene/ perylenes	C4-252 isomers, C4-alkylated Benzopyrene/ perylenes	C5-228 isomers, C5-benzo(a)--Anthracene/ chrysenes	C5-252 isomers, C5-alkylated Benzopyrene/ perylenes	Coron-ene
					Test plots						
MON	<10,000	<30,000	<9,000	76,000	90,000	18,000	<15,000	<15,000	<9,000	<30,000	E20,000
TAR	<15,000	<35,000	<10,000	86,000	100,000	21,000	<15,000	<11,000	<10,000	<30,000	E25,000
PAV	<19,000	<19,000	<19,000	E9,100	E8,400	<19,000	<19,000	<19,000	<19,000	<19,000	E7,300
ASP	<6,700	<20,000	<6,700	42,000	48,000	11,000	<8,500	<6,700	<6,700	<20,000	E13,000
MON	<14,000	<22,000	<16,000	40,000	E53,000	14,000	<14,000	<12,000	<12,000	<15,000	12,000
TAR	E55,000	<170,000	<95,000	340,000	E280,000	82,000	<80,000	<58,000	<54,000	<110,000	94,000
PAV	<1,500	<4,000	<2,000	5,600	4,900	1,600	<3,000	<2,500	<1,500	<6,000	2,200
ASP	<1,000	<3,000	<1,500	3,500	3,400	1,300	<2,500	<2,500	<1,000	<4,500	1,400
MON	<7,500	<22,000	<7,500	33,000	35,000	6,000	<5,500	<8,500	<3,500	<12,000	9,700
TAR	<3,500	<9,000	<5,000	16,000	16,000	4,800	<5,000	<5,000	<3,500	<7,500	5,000
PAV	<4,000	<7,000	<4,000	7,900	6,400	<4,000	<5,000	<6,000	<4,000	<6,000	E3,900
ASP	<5,000	<5,000	<5,000	E3,000	E2,400	<5,000	<5,000	<5,000	<5,000	<5,000	E2,000
MON	<150,000	<980,000	<620,000	3,300,000	E4,800,000	280,000	<300,000	<300,000	<150,000	<1,200,000	1,000,000
TAR	<35,000	<300,000	<150,000	660,000	E980,000	64,000	<150,000	<65,000	<45,000	<250,000	170,000
PAV	<3,000	<10,000	<5,000	11,000	11,000	<2,500	<9,500	<6,500	<4,500	<11,000	3,700
					Parking lots in use						
TCQ	<20,000	E94,000	<38,000	180,000	E260,000	32,000	<41,000	<26,000	<16,000	<47,000	52,000
SSE	<12,000	<15,000	<12,000	38,000	E45,000	10,000	<18,000	<12,000	<12,000	<15,000	15,000
SSE duplicate	<10,000	<20,000	<14,000	34,000	E37,000	9,800	<14,000	<10,000	<11,000	<12,000	12,000
WWB	E10,000	E48,000	<22,000	86,000	E92,000	19,000	<21,000	<14,000	<13,000	<26,000	24,000
LAC	<3,500	<6,500	<4,200	8,300	E8,600	3,600	<5,000	<4,000	<4,000	<4,500	3,200

Table 2. Particulate-phase concentrations of polycyclic aromatic hydrocarbons in washoff and scrapings samples from parking lots, Austin, Texas, 2003—Continued.

Site name	C3-228 isomers, C3-Benzo(a)-anthracene/ chrysenes	C2-252 isomers, C2-alkylated Benzopyrene/ perylenes	C4-228 isomers, C4-Benzo(a)-anthracene/ chrysenes	Benzo-(g,h,i)-perylene	Indeno-(1,2,3-c,d)-pyrene	Dibenzo-(a,h)-anthra-cene	C3-252 isomers, C3-alkylated Benzopyrene/ perylenes	C4-252 isomers, C4-alkylated Benzopyrene/ perylenes	C5-228 isomers, C5-benzo(a)-- Anthracene/ chrysenes	C5-252 isomers, C5-alkylated Benzopyrene/ perylenes	Coron-ene
					Parking lots in use—Continued						
LOW	<2,600	<5,800	<3,400	8,500	E6,300	2,800	<4,000	<3,200	<3,700	<4,200	3,400
NWR	<6,000	<10,000	<6,500	9,800	E12,000	<4,500	<7,500	<6,000	<6,500	<5,500	E4,400
LBJ	<40,000	<480,000	<130,000	830,000	960,000	170,000	<160,000	<140,000	<46,000	<550,000	200,000
UTN	<12,000	<150,000	<40,000	290,000	320,000	56,000	<48,000	<46,000	<14,000	<190,000	72,000
SOC	<14,000	<52,000	<22,000	76,000	76,000	23,000	<32,000	<30,000	<23,000	<62,000	28,000
CNR	<14,000	<82,000	<32,000	160,000	170,000	28,000	<30,000	<19,000	<12,000	<48,000	39,000
OSL	<7,500	<49,000	<18,000	72,000	77,000	15,000	<21,000	<11,000	<7,000	<26,000	18,000
UNF	<42,000	<370,000	<130,000	850,000	880,000	220,000	<87,000	<77,000	<26,000	<260,000	210,000
UNF duplicate	<26,000	<21,000	<72,000	520,000	530,000	88,000	<52,000	<38,000	<16,000	<150,000	110,000
ZLK	<2,000	<3,000	<2,000	2,100	E1,600	<2,000	<3,000	<2,500	<2,000	<3,000	E1,500
TCQ	<84,000	<760,000	<320,000	1,700,000	E2,500,000	350,000	<280,000	<180,000	<110,000	<500,000	490,000
SSE	<17,000	<25,000	<22,000	31,000	E46,000	18,000	<21,000	<16,000	<21,000	<16,000	E9,200
WWB	<48,000	<140,000	<76,000	240,000	E240,000	70,000	<78,000	<52,000	<62,000	<90,000	72,000
NWR	<500	<1,500	<600	980	860	<500	<2,000	<1,500	<600	<2,000	E470
LBJ	<41,000	<560,000	<150,000	1,000,000	1,200,000	270,000	<150,000	<170,000	<41,000	<680,000	240,000
UTN	<46,000	<610,000	<180,000	1,200,000	1,200,000	260,000	<180,000	<180,000	<52,000	<870,000	320,000
CNR	<31,000	<420,000	<140,000	820,000	940,000	200,000	<160,000	<93,000	<59,000	<540,000	180,000
OSL	<44,000	<770,000	<210,000	1,100,000	1,200,000	280,000	<260,000	<220,000	<79,000	<740,000	260,000
UNF	<43,000	<610,000	<160,000	1,200,000	1,300,000	240,000	<160,000	<150,000	<48,000	<750,000	290,000
ZLK	<8,500	<12,000	<8,500	<8,500	<8,500	<8,500	<12,000	<13,000	<8,500	<12,000	<8,500

Table 3. Dissolved-phase concentrations of polycyclic aromatic hydrocarbons in washoff samples from parking lots, Austin, Texas, 2003.

[In micrograms per liter. ΣPAH_{diss}, total dissolved polycyclic hydrocarbons (for complete definition see text); E, estimated; <, less than.]

Site name	Type of surface	Sampling date	ΣPAH_{diss}	Acenaphthylene	Acenaphthene	Anthracene	Benzo-[b]-fluoranthene	Benzo-[k]-fluoranthene	Benzo-[a]-pyrene	Chrysene	Fluoranthene	9H-Fluorene	Indeno-pyrene	Nitrobenzene	Phenanthrene	Pyrene	Benz-[ghi]-perylene	Benz-[a]-anthracene	Dibenz-[ah]-anthracene	Naphthalene
									Test plots											
MON	coal-tar-emulsion-sealed	8/12/2003	21	E0.56	E0.39	E1.4	<1.9	<1.7	<1.3	<2.7	4.1	E0.94	<3.0	<2.0	11	E2.1	<2.8	<2.4	<3.4	E1.1
MON	coal-tar-emulsion-sealed	8/21/2003	14	E.17	E.36	E1.0	<1.9	<1.7	<1.3	<2.7	2.6	E.61	<3.0	<2.0	7.3	E1.1	<2.8	<2.4	<3.4	E1.2
MON	coal-tar-emulsion-sealed	9/26/2003	6.9	E.03	E.05	E.29	<1.9	<1.7	<1.3	E.25	2.9	E.13	<3.0	<2.0	E1.9	E1.3	<2.8	<2.4	<3.4	E.10
TAR	coal-tar-emulsion-sealed	8/12/2003	11	E.39	E.31	E1.5	<1.9	<1.7	<1.3	<2.7	E1.0	E.78	<3.0	<2.0	5.5	E.67	<2.8	<2.4	<3.4	E1.1
TAR	coal-tar-emulsion-sealed	8/21/2003	7.3	E.35	<1.8	E.77	<1.9	<1.7	<1.3	<2.7	E1.2	E.37	<3.0	<2.0	2.8	E.49	<2.8	<2.4	<3.4	E1.3
TAR	coal-tar-emulsion-sealed	9/26/2003	3.8	E.14	E.06	E.56	<1.9	<1.7	<1.3	E.05	E1.2	E.14	<3.0	<2.0	E1.0	E.56	<2.8	<2.4	<3.4	E.13
PAV	asphalt-emulsion-sealed	8/12/2003	1.3	<2.4	<1.8	<2.0	<1.9	<1.7	<1.3	<2.7	E0.31	<2.0	<3.0	<2.0	E.87	E.12	<2.8	<2.4	<3.4	<1.8
PAV	asphalt-emulsion-sealed	8/21/2003	1.2	<2.4	<1.8	E.23	<1.9	<1.7	<1.3	<2.7	E.30	<2.0	<3.0	<2.0	E.52	E.13	<2.8	<2.4	<3.4	<1.8
PAV	asphalt-emulsion-sealed	9/26/2003	.64	<2.4	<1.8	E.09	<1.9	<1.7	<1.3	<2.7	E.18	<2.0	<3.0	<2.0	E.18	E.08	<2.8	<2.4	<3.4	E.12
ASP	unsealed asphalt	8/12/2003	.16	<2.4	<1.8	<2.0	<1.9	<1.7	<1.3	<2.7	<2.4	<2.0	<3.0	<2.0	E.08	<2.2	<2.8	<2.4	<3.4	E.08
ASP	unsealed asphalt	8/21/2003	.34	<2.4	<1.8	<2.0	<1.9	<1.7	<1.3	<2.7	E.05	<2.0	<3.0	<2.0	E.14	E.03	<2.8	<2.4	<3.4	E.11
ASP	unsealed asphalt	9/26/2003	.17	<2.4	<1.8	<2.0	<1.9	<1.7	<1.3	<2.7	E.05	<2.0	<3.0	<2.0	E.05	E.02	<2.8	<2.4	<3.4	E.05
									Parking lots in use											
CNR	coal-tar-emulsion-sealed	9/30/2003	12	E.15	E.04	E.85	<1.9	<1.7	<1.3	<2.7	4.2	E.24	<3.0	<2.0	4.6	2.2	<2.8	<2.4	<3.4	E.08
LBJ	coal-tar-emulsion-sealed	9/28/2003	5.4	<2.4	E.03	E.29	E.06	<1.7	<1.3	E.12	E2.0	E.09	<3.0	<2.0	E1.8	E.92	<2.8	<2.4	<3.4	E.08
OSL	coal-tar-emulsion-sealed	9/30/2003	2.3	E.05	<1.8	E.16	<1.9	<1.7	<1.3	E.04	E1.1	E.04	<3.0	<2.0	E.47	E.35	<2.8	<2.4	<3.4	E.09
UNF	coal-tar-emulsion-sealed	9/30/2003	16	<2.4	<1.8	E.79	<1.9	<1.7	<1.3	<2.7	8.7	E.10	<3.0	<2.0	3.6	2.3	<2.8	<2.4	<3.4	E.17
UTN	coal-tar-emulsion-sealed	9/28/2003	7.1	<2.4	<1.8	.53	E.30	<1.7	<1.3	E.41	2.9	E.01	<3.0	<2.0	E1.1	E2.1	<2.8	<2.4	<3.4	E.10
SOC	asphalt-emulsion-sealed	9/28/2003	5.1	<2.4	<1.8	.42	E.09	<1.7	<1.3	E.09	E1.7	<2.0	<3.0	<2.0	E1.8	E.97	<2.8	<2.4	<3.4	E.07
ZLK	unsealed asphalt	9/30/2003	.24	<2.4	<1.8	<2.0	<1.9	<1.7	<1.3	<2.7	E.09	<2.0	<3.0	<2.0	E.05	E.04	<2.8	<2.4	<3.4	E.06

Table 4. Particulate-phase concentrations of major and trace elements in washoff samples from parking lots, Austin, Texas, 2003.

[In milligrams per kilogram. Isa, insufficient sediment mass for analysis; --, not analyzed; Note: Data analyzed by custom method and therefore not available in USGS National Water Information System (NWIS) database.]

Site name	Type of surface	Date	Aluminum	Calcium	Iron	Potassium	Magnesium	Sodium	Phosphorus	Titanium	Arsenic
					Test plots						
MON	coal-tar emulsion-sealed	8/21/2003	45,000	156,000	20,200	7,320	5,070	990	417	2,230	6.5
TAR	coal-tar emulsion-sealed	8/21/2003	16,400	23,000	8,720	3,600	8,760	1,310	1,740	1,130	3.4
PAV	asphalt-emulsion-sealed	8/21/2003	20,000	110,000	12,500	6,710	51,100	2,510	1,520	1,700	4.7
ASP	unsealed asphalt	8/21/2003	14,800	29,200	7,840	3,470	10,500	1,180	1,830	1,080	3.3
MON	coal-tar emulsion-sealed	9/9/2003	23,900	39,500	9,400	4,430	13,700	1,450	1,400	1,500	4.3
TAR	coal-tar emulsion-sealed	9/9/2003	22,900	26,700	9,300	3,960	8,300	1,360	1,400	1,500	4.4
PAV	asphalt-emulsion-sealed	9/9/2003	80,300	5,870	11,500	3,980	2,930	727	1,170	6,010	3.2
ASP	unsealed asphalt	9/9/2003	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa
MON	coal-tar emulsion-sealed	9/26/2003	79,900	21,800	12,000	4,520	9,440	907	1,300	5,100	3.4
TAR	coal-tar emulsion-sealed	9/26/2003	122,000	5,360	13,000	3,840	2,790	532	1,200	10,000	3.0
PAV	asphalt-emulsion-sealed	9/26/2003	19,700	50,600	4,300	4,570	23,800	1,250	750	1,100	1.0
ASP	unsealed asphalt	9/26/2003	12,600	102,000	5,200	6,340	42,200	1,930	620	680	2.0
					Parking lots in use						
TCQ	coal-tar emulsion-sealed	9/7/2003	24,500	73,300	12,600	6,710	10,800	2,660	840	2,500	5.4
SSE	asphalt-emulsion-sealed	9/7/2003	26,800	13,400	6,040	2,330	4,030	610	358	2,590	2.1
WWB	asphalt-emulsion-sealed	9/7/2003	23,600	11,600	4,940	1,700	2,570	325	183	2,180	2.0
WWB replicate	asphalt-emulsion-sealed	9/7/2003	21,700	9,130	4,210	1,950	1,890	417	148	1,880	1.5
WWB replicate	asphalt-emulsion-sealed	9/7/2003	23,400	11,500	4,890	1,670	2,470	312	175	2,150	1.6
LAC	unsealed concrete	9/8/2003	18,000	147,000	14,200	6,080	15,300	3,500	709	1,890	3.2
LOW	unsealed concrete	9/8/2003	18,200	123,000	14,200	5,670	10,900	2,080	1,010	2,350	5.1
NWR	unsealed asphalt	9/8/2003	11,000	172,000	7,470	3,310	18,800	1,320	809	1,140	2.9
LBJ	coal-tar emulsion-sealed	9/28/2003	25,000	66,000	13,000	4,400	7,980	1,390	970	2,400	4.0
UTN	coal-tar emulsion-sealed	9/28/2003	27,000	86,300	12,000	4,560	7,770	1,510	990	2,500	3.7
SOC	asphalt-emulsion-sealed	9/28/2003	35,700	41,600	12,000	4,860	6,140	1,480	990	3,100	3.0
SOC replicate	asphalt-emulsion-sealed	9/28/2003	35,500	41,000	12,000	4,920	5,910	1,400	980	2,800	2.0
SOC replicate	asphalt-emulsion-sealed	9/28/2003	34,100	39,800	12,000	4,740	5,890	1,440	930	3,000	2.0
CNR	coal-tar emulsion-sealed	9/30/2003	27,000	32,800	9,300	3,710	6,950	1,020	1,200	2,400	3.4
OSL	coal-tar emulsion-sealed	9/30/2003	8,670	11,400	2,800	1,480	1,620	585	210	810	1.0
UNF	coal-tar emulsion-sealed	9/30/2003	23,400	54,600	11,000	4,100	5,540	1,480	1,400	2,000	4.6
ZLK	unsealed asphalt	9/30/2003	15,600	187,000	8,000	6,160	16,600	2,620	660	1,100	4.6
ZLK replicate	unsealed asphalt	9/30/2003	15,200	192,000	8,200	6,010	16,200	2,690	600	1,100	29.0

Table 4. Particulate-phase concentrations of major and trace elements in washoff samples from parking lots, Austin, Texas, 2003—Continued.

Site name	Barium	Beryllium	Cadmium	Cobalt	Chromium	Copper	Mercury	Lithium	Manganese	Nickel	Lead	Scandium	Strontium	Vanadium	Zinc
Test plots															
MON	187	1.4	3.51	6.2	91.6	34.8	0.08	30.5	238	26.7	85.6	7.4	200	64.9	214
TAR	154	.5	5.16	2.6	46.0	61.4	Isa	8.0	88.9	21.1	89.8	2.8	60.2	25.0	218
PAV	255	.6	2.04	4.4	79.1	147	Isa	10.0	221	32.5	220	3.2	171	32.8	625
ASP	145	.6	1.24	2.8	36.4	46.5	.04	7.6	104	15.6	98.9	2.7	54.8	23.9	349
MON	157	.6	.86	3.1	53.2	52.2	Isa	12.5	137	13.0	114	3.3	60.7	32.9	356
TAR	195	.6	.64	3.0	49.6	49.0	Isa	13.4	127	13.9	82.8	3.5	67.5	34.2	309
PAV	189	.8	.17	2.5	73.9	28.5	.08	33.9	52.9	16.1	44.7	11.8	65.7	92.7	96.3
ASP	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa	Isa
MON	176	.9	1.50	4.2	121	57.9	Isa	33.0	112	21.1	228	8.8	74.9	84.2	653
TAR	164	1.2	.22	2.7	128	25.3	.10	50.8	40.2	17.5	96.9	14.5	82.3	140	313
PAV	117	.5	.57	2.0	36.3	29.7	.13	7.4	111	10.9	78.3	2.2	47.9	23.5	237
ASP	162	.4	.88	2.0	85.3	33.5	Isa	4.4	111	8.8	246	1.7	71.0	18.7	1,880
Parking lots in use															
TCQ	264	.7	1.87	4.1	92.8	69.0	.08	13.7	206	20.9	268	4.0	99.2	35.0	1,200
SSE	131	.4	.49	2.8	51.1	23.8	.05	14.1	64.9	15.7	119	3.5	39.7	53.8	477
WWB	160	.4	.41	1.5	31.8	34.6	.02	12.0	36.8	12.6	35.4	3.0	29.5	39.4	306
WWB replicate	127	.3	.36	1.0	26.6	19.1	--	11.1	28.9	10.6	27.1	2.7	27.6	36.4	241
WWB replicate	160	.3	.40	1.5	31.4	33.8	--	11.6	37.0	12.5	34.8	3.0	29.5	38.9	302
LAC	536	.7	.81	6.0	164	124	.24	8.7	252	55.3	321	2.8	272	27.5	1,420
LOW	246	.6	.68	11.9	385	78.8	.05	11.3	400	35.1	577	3.3	143	35.2	1,770
NWR	152	.3	.60	2.8	38.4	48.3	.03	6.9	151	26.4	75.9	2.1	86.8	49.3	1,070
LBJ	439	.7	2.10	6.0	90.5	143	.18	12.4	188	22.4	223	4.0	95.9	37.5	2,570
UTN	257	.6	1.90	5.3	78.1	71.9	.26	12.1	166	17.6	174	4.2	112	41.2	2,000
SOC	268	.7	.87	3.7	68.8	76.2	.09	15.8	132	22.9	115	5.1	83.1	59.8	1,180
SOC replicate	274	.7	.88	3.8	62.7	79.9	--	15.8	129	22.0	116	4.8	85.5	58.9	1,190
SOC replicate	269	.7	.89	3.7	65.9	74.0	--	15.6	129	22.4	116	4.8	84.0	58.0	1,170
CNR	199	.5	1.80	4.2	45.1	46.0	.09	12.7	123	15.3	74.1	3.8	75.6	41.0	1,470
OSL	59.8	.2	.33	1.1	40.4	24.5	.05	3.7	43.7	4.3	135	1.1	19.1	10.5	173
UNF	174	.5	1.20	9.1	108	65.6	.07	10.1	153	49.2	74.3	3.2	63.1	30.4	518
ZLK	184	.6	.41	2.7	24.8	26.9	.05	6.8	213	7.7	37.2	2.6	123	24.2	345
ZLK replicate	178	.5	.38	2.7	77.9	29.8	.04	6.4	221	12.6	34.6	2.6	127	22.7	317

Table 5. Suspended sediment concentrations in washoff samples from parking lots, Austin, Texas, 2003.

[mg/L, milligrams per liter; µm, micrometers; L, liters; --, not applicable]

Site name	Sampling date	Sample[1]	Suspended sediment concentration (mg/L)	Percent greater than 63 µm	Percent less than 63 µm	Volume sample represents[2] (L)	Approach for calculating average concentration	Average suspended sediment concentration[3] (mg/L)
MON	8/12/03	1	13	59.8	40.2	--	No sediment chemistry	--
MON	8/21/03	1	38	12.8	87.2	--	Single sample	--
TAR	8/21/03	1	31	33.8	66.2	--	Single sample	--
PAV	8/21/03	1	40	16.9	83.1	--	Mean of two samples	41
		2	42	16.5	83.5			
ASP	8/21/03	1	48	18.5	81.5	--	Single sample	--
MON	9/9/03	1	17	29.8	70.2	--	Mean of two samples	16
		2	14	6.3	93.8			
TAR	9/9/03	1	25	42.4	57.6	--	Mean of two samples	22
		2	19	12.1	87.9			
PAV	9/9/03	1	48	4.8	95.2	--	Mean of two samples	56
		2	64	20.7	79.3			
ASP	9/9/03	1	54	39.0	61.0	--	Single sample	--
MON	9/26/03	1	7	0	100	--	Mean of two samples	8
		2	8	0	100			
TAR	9/26/03	1	16	17.6	82.4	--	Ignored sample 2[4]	16
		2	5	28.0	72.0			
		3	16	52.5	47.5			
PAV	9/26/03	1	42	9.8	90.2	50	Volume-weighted mean	36
		2	22	7.8	92.2	22		
ASP	9/26/03	1	28	62.7	37.3	--	Single sample	--
TCQ	9/7/03	1	92	48.7	51.3	24	Volume-weighted mean	67
		2	54	28.3	71.7	46		
SSE	9/7/03	1	121	41.4	58.6	--	Mean of two samples	180
		2	238	64.9	35.1	--		

Table 5. Suspended sediment concentrations in washoff samples from parking lots, Austin, Texas, 2003—Continued.

Site name	Sampling date	Sample[1]	Suspended sediment concentration (mg/L)	Percent greater than 63 µm	Percent less than 63 µm	Volume sample represents[2] (L)	Approach for calculating average concentration	Average suspended sediment concentration[3] (mg/L)
WWB	9/7/03	1	137	40.1	59.9	--	Mean of two samples	197
		2	256	57.0	43.0	--		
LAC	9/8/03	1	157	42.2	57.8	--	Mean of two samples	129
		2	101	32.5	67.5	--		
LOW	9/8/03	1	113	30.4	69.6	--	Mean of two samples	109
		2	104	26.5	73.5	--		
NWR	9/8/03	1	323	51.9	48.1	--	Ignored sample 2[4]	323
		2	1,004	80.1	19.9	--		
LBJ	9/28/03	1	142	36.0	64.0	45	Volume-weighted mean	122
		2	86	40.3	59.7	25		
UTN	9/28/03	1	782	60.5	39.5	50	Volume-weighted mean	594
		2	218	57.3	42.7	25		
SOC	9/28/03	1	1,047	70.2	29.8	45	Volume-weighted mean	732
		2	164	46.3	53.7	25		
CNR	9/30/03	1	62	30.8	69.2	50	Volume-weighted mean	53
		2	25	22.6	77.5	16		
OSL	9/30/03	1	148	56.5	43.5	--	Single sample	--
UNF	9/30/03	1	160	63.3	36.7	47	Volume-weighted mean	125
		2	50	35.2	64.8	22		
ZLK	9/30/03	1	377	22.9	77.1	45	Volume-weighted mean	358
		2	249	26.0	74.0	8		

[1] Order of sample collection from churn during filtration.

[2] Some samples collected beginning 9/26/05 from a known volume of total sample thus allowing calculation of volume-weighted mean concentration.

[3] Mean or volume-weighted concentration of washoff sample.

[4] Ignored outlier based on comparison of suspended sediment concentration to mass of sediment recovered during filtration.